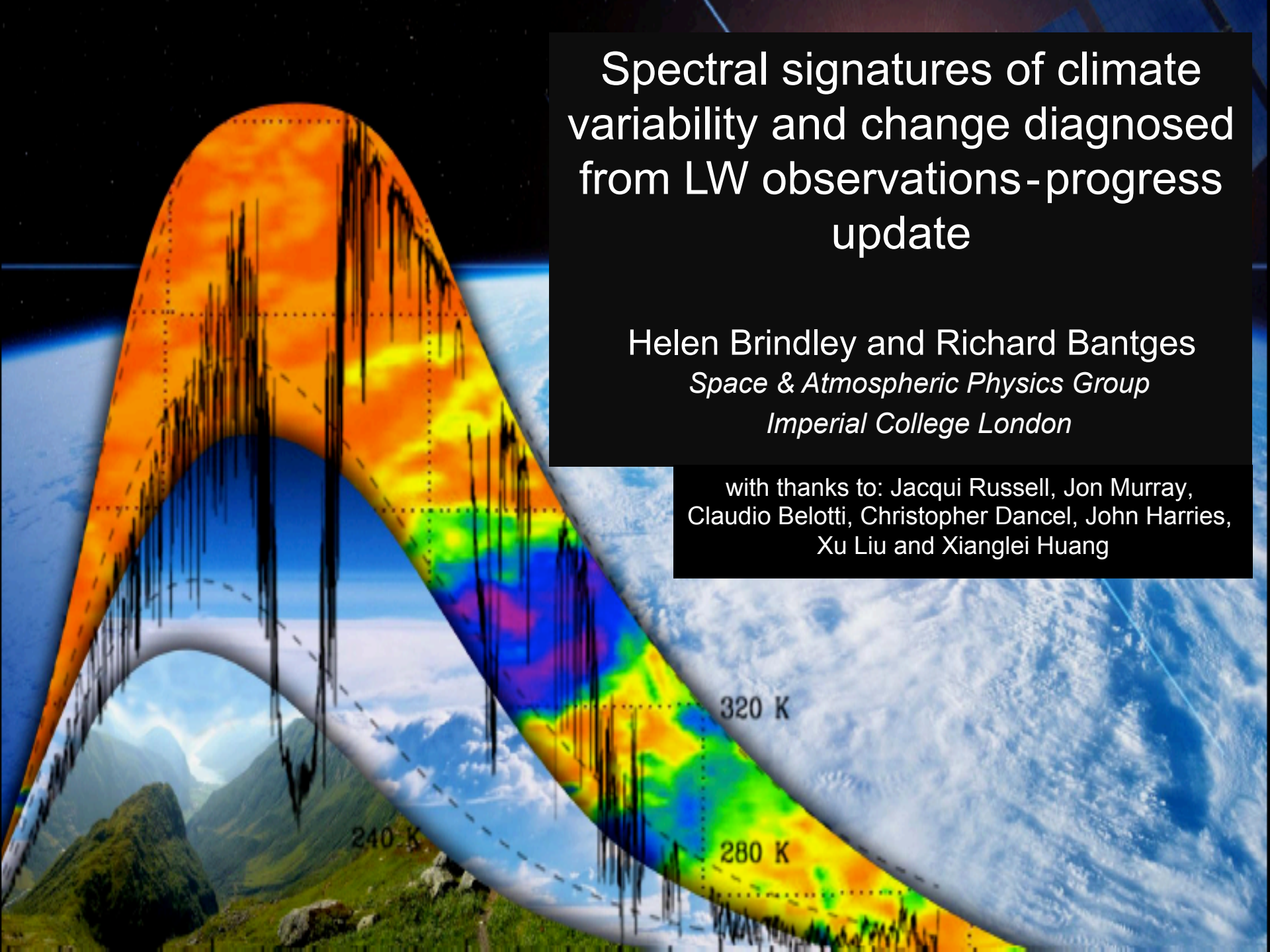
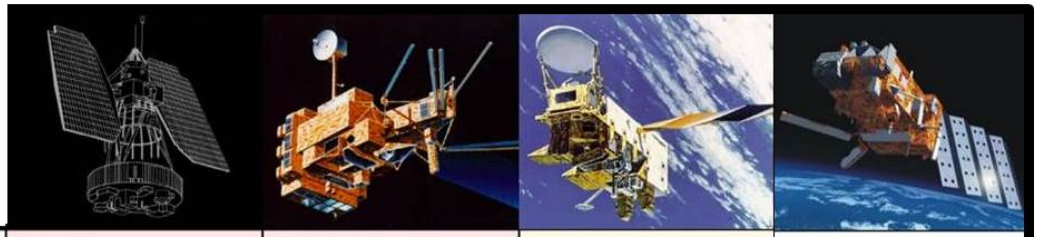


Spectral signatures of climate variability and change diagnosed from LW observations - progress update

Helen Brindley and Richard Bantges
Space & Atmospheric Physics Group
Imperial College London

with thanks to: Jacqui Russell, Jon Murray, Claudio Belotti, Christopher Dancel, John Harries, Xu Liu and Xianglei Huang

Can we use current/past instruments to get us part way there?



Instrument	IRIS	IMG	AIRS	IASI
Satellite	Nimbus 4	ADEOS	AQUA	METOP-A
Spectro-meter type	FTS	FTS	grating spectrometer	FTS
Data available	Apr 1970 – Jan 1971	Oct 1996 – Jun 1997	2002 - present	2007 - present
Spectral coverage (cm^{-1})	400 – 1600 cm^{-1} continuous	715 – 3030 cm^{-1} 3 bands	650 – 2700 cm^{-1} 2378 bands	645 – 2760 cm^{-1} 3 bands
Spectral resolution	2.8 cm^{-1}	0.1 cm^{-1}	0.4–1.0 cm^{-1}	0.5 cm^{-1}
Footprint (nadir)	95 km diameter	8km x 8km	13 km diameter	12 km diameter

Clear-sky only, no account of variability

Harries et al., 2001

→ Griggs and Harries, 2007 ←

IASI and IRIS?
IASI and IMG?

Major Questions

- What is the short-term variability seen in observed radiance spectra?
- How do these signals compare to those seen in model simulations and what can this tell us about the representation of the processes driving variability/change?
- Are observed long-term change signals robust?

Major Questions

- What is the short-term variability seen in observed radiance spectra?
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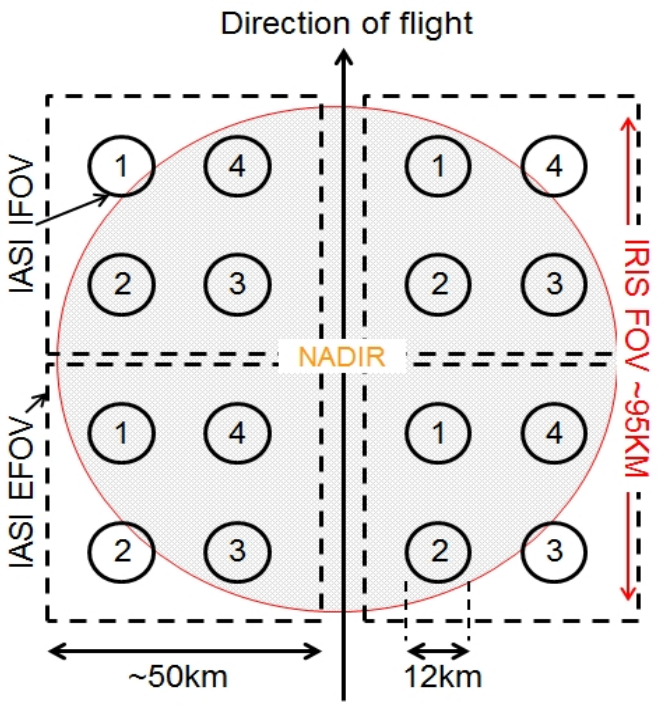
Ensure measurements are as consistent as possible

Spatial consistency:
average 16 IASI IFOV footprints



5 years of IASI L1c data: ~ 50 Tb
~ 160 million spectra
(now archiving 2013-2014)

Spectral consistency

IRIS

Pad each spectrum to 0-2000 cm^{-1} at original sampling interval

↓

FT padded spectrum

↓

FT and output at 0.1 cm^{-1} sampling interval (~ 2.8 cm^{-1} resolution)

IASI

Pad and truncate average spectra to 0-2000 cm^{-1} at original sampling interval

↓

FT, remove IASI apodisation function & apply varying length Hamming window

↓

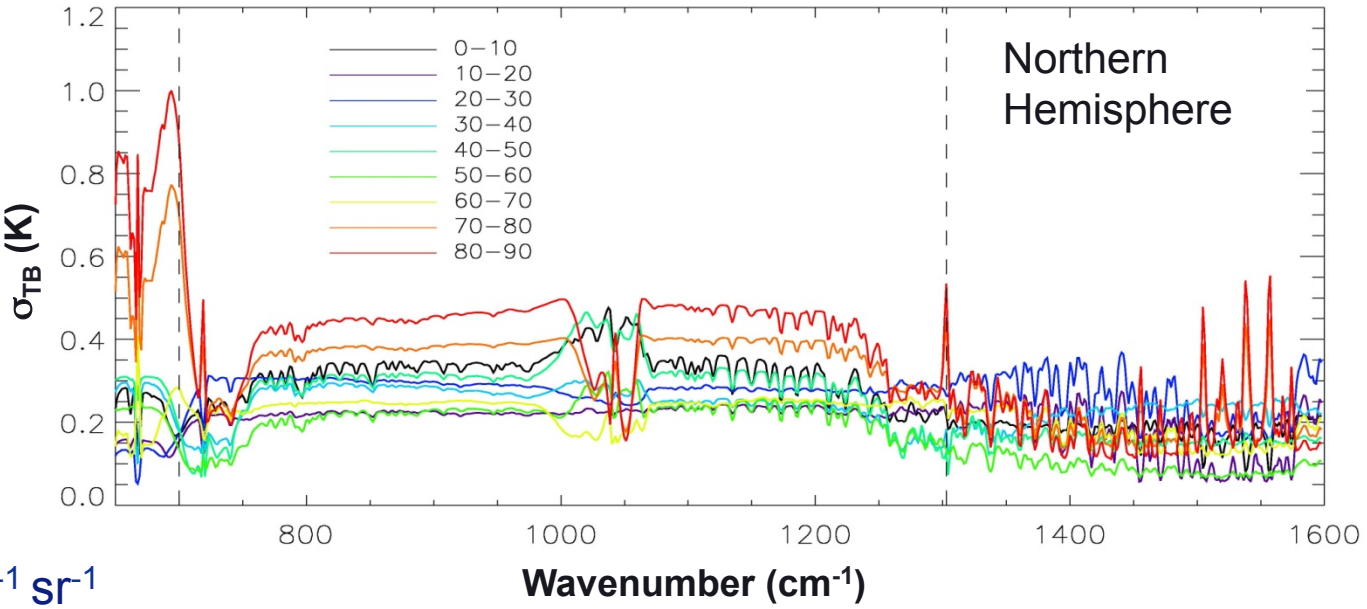
FT output at 0.1 cm^{-1} sampling interval (~ 2.8 cm^{-1} resolution)

↓

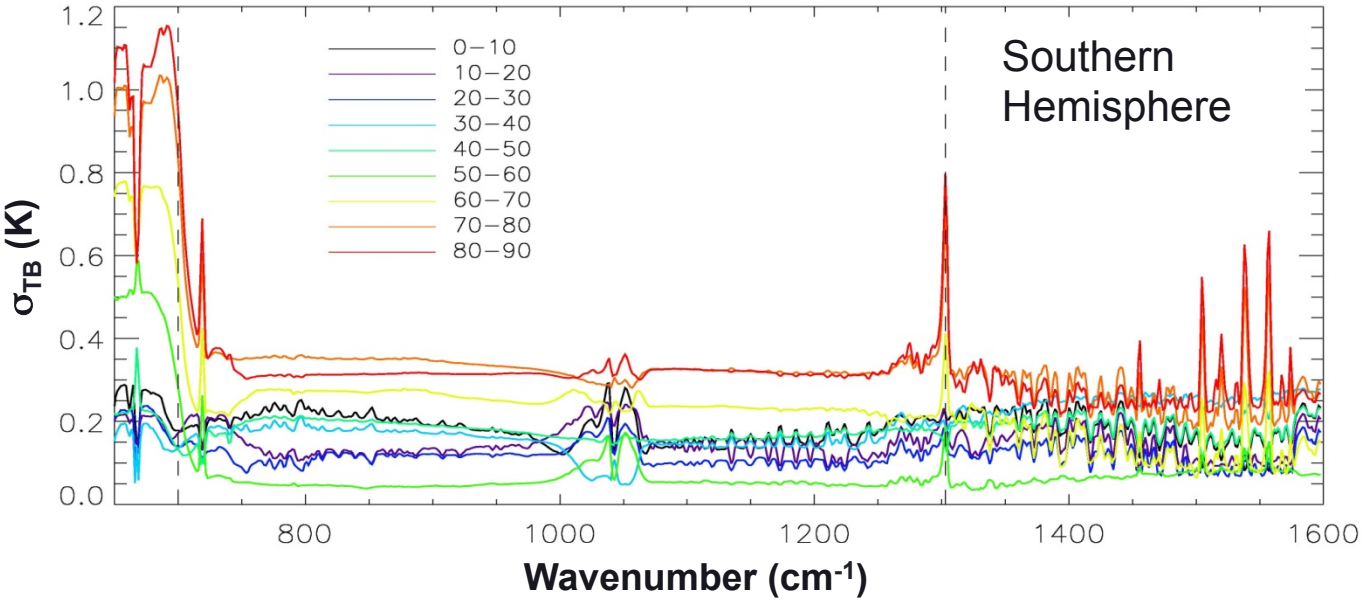
Apply remaining FOV correction factor

Short-term spectral variability

Standard deviation in **10° latitude band** annual means

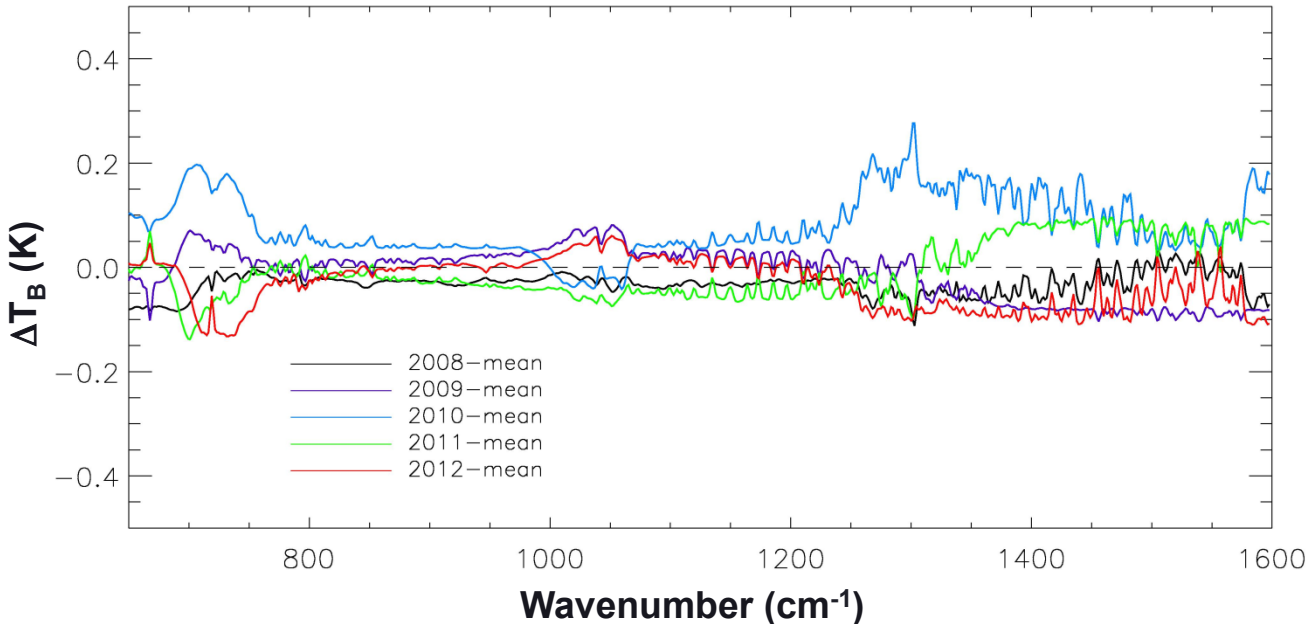


1 K ~ 1 mW m^{-2} $(cm^{-1})^{-1}$ sr^{-1}

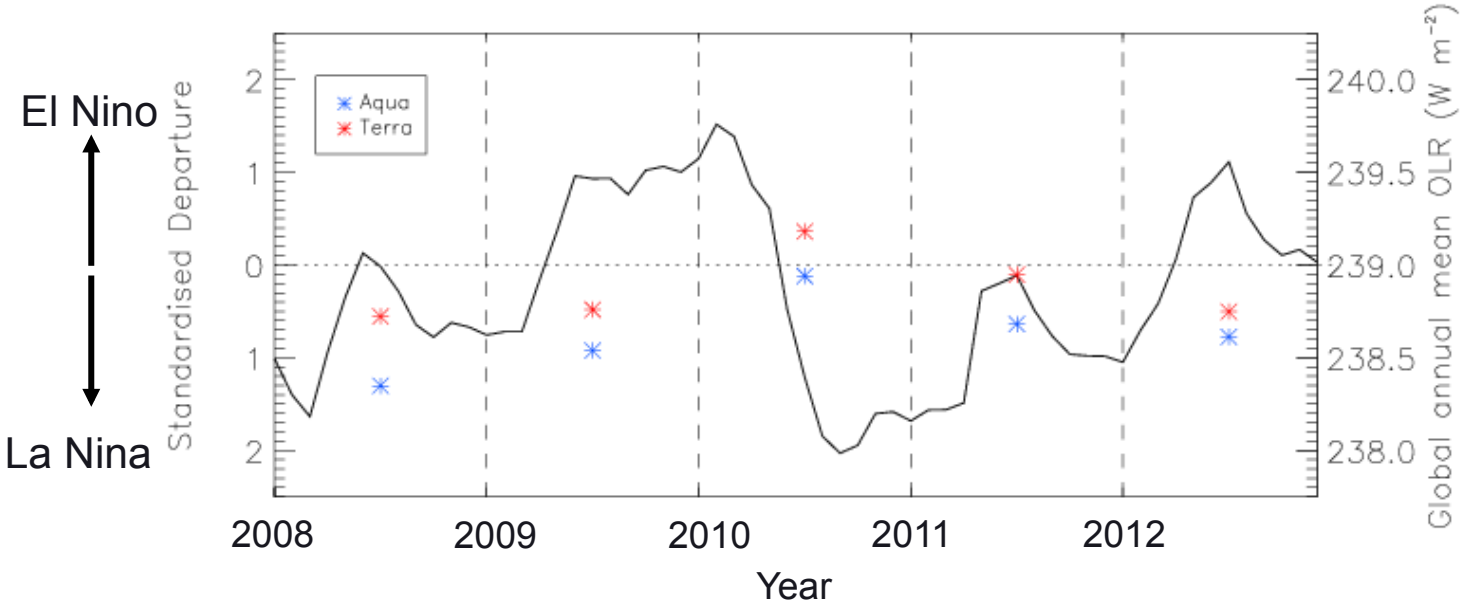


Short-term spectral variability

Deviation from overall global annual mean for each year

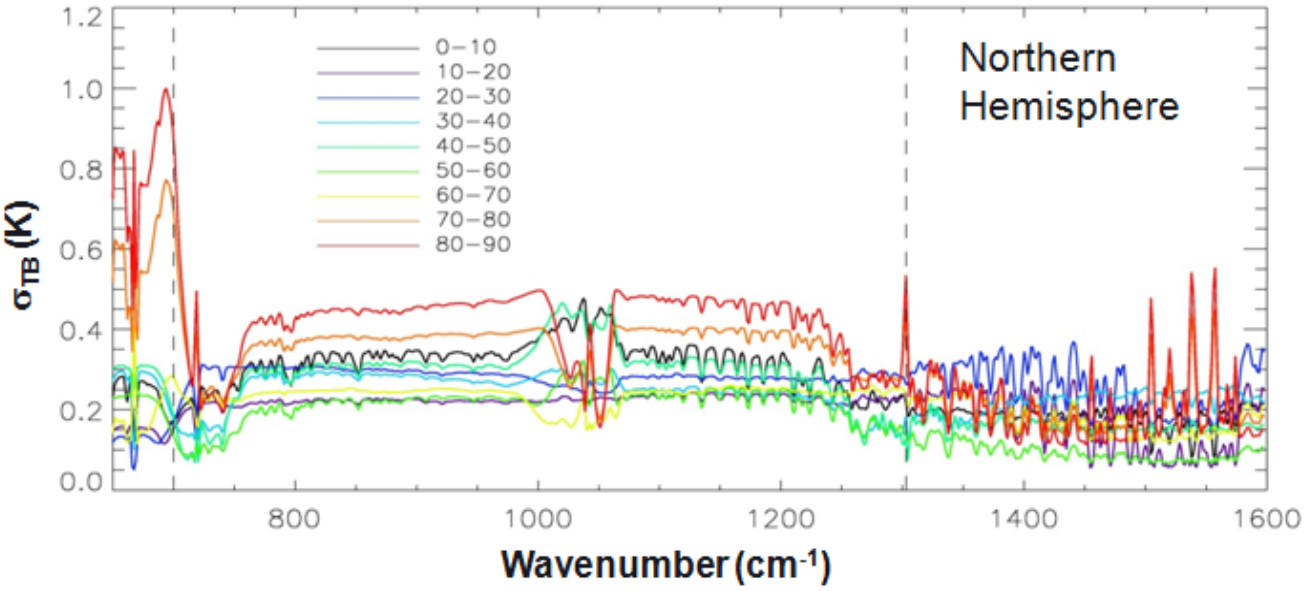


Multivariate ENSO Index (NOAA ESRL) [black]
CERES OLR [blue and red]

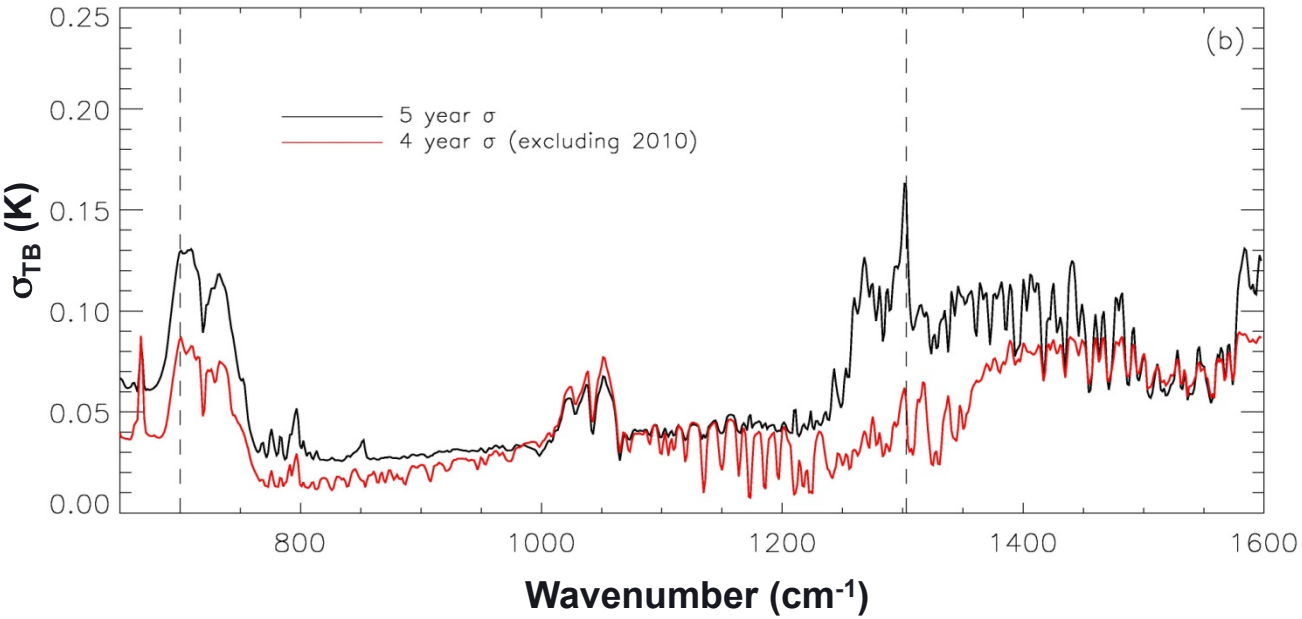


Short-term spectral variability

Standard deviation in **10° latitude band** annual means

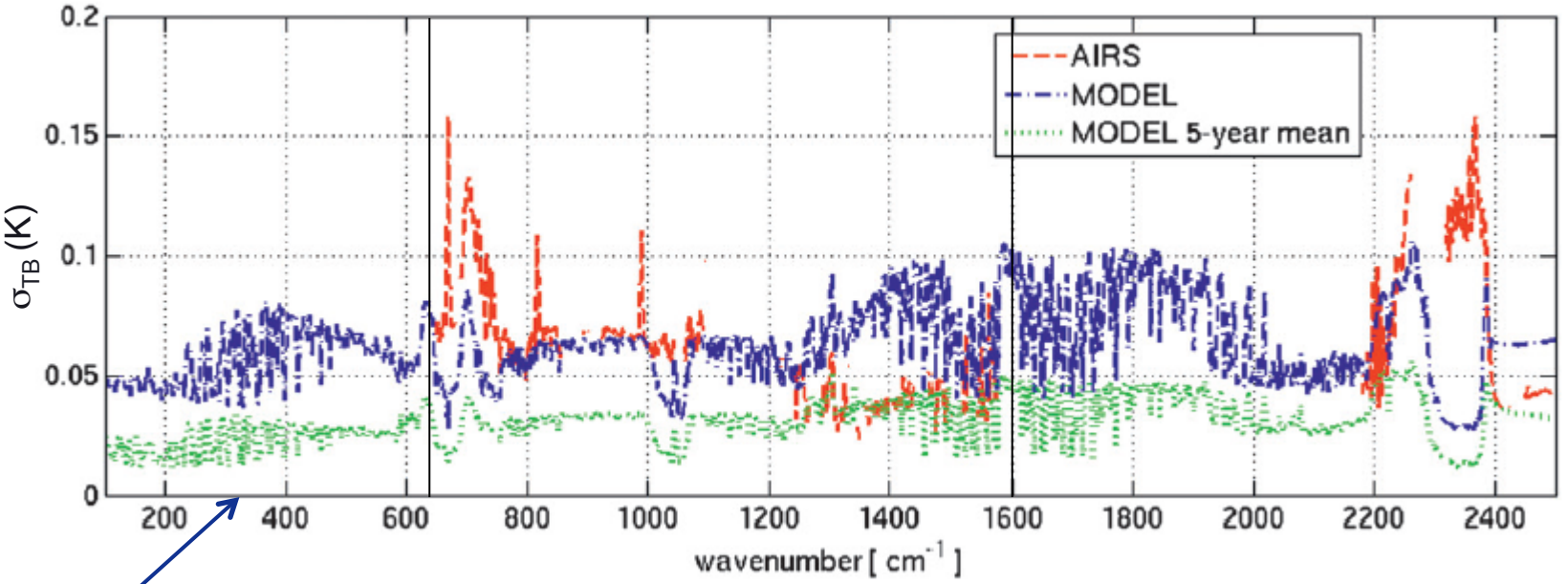


Standard deviation in global annual means

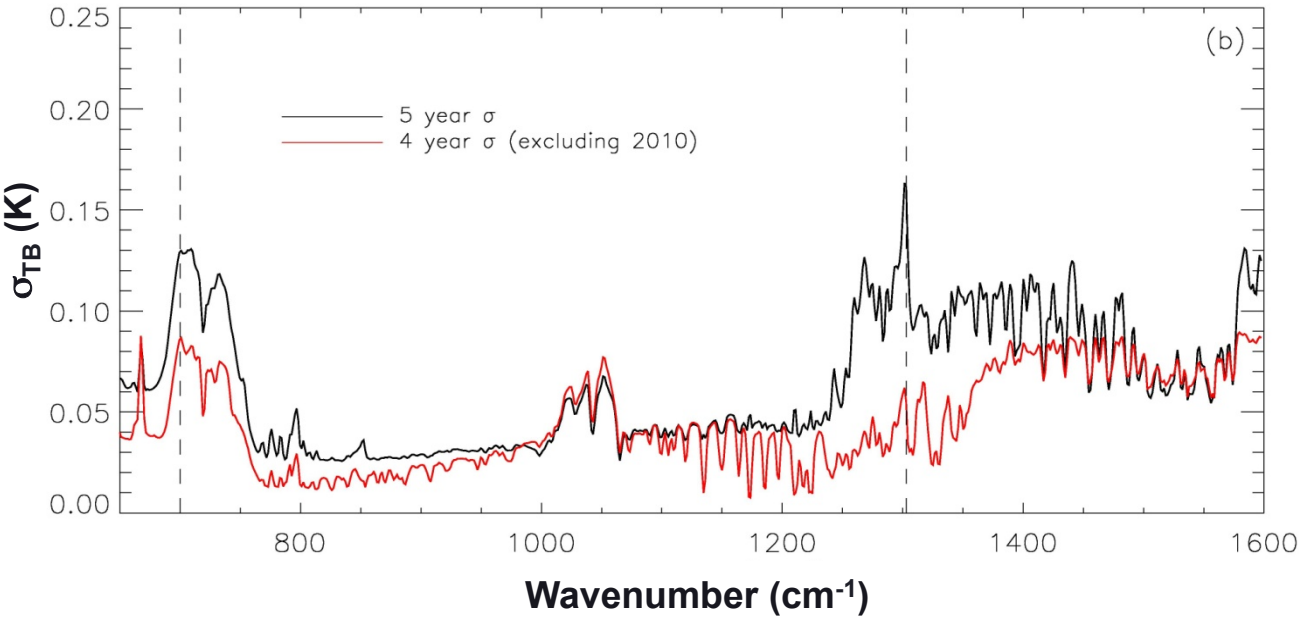


Note change in scale and change in shape

Short-term spectral variability



Huang and Ramaswamy, (2009)
AIRS: 2002-2007
GFDL, CM2

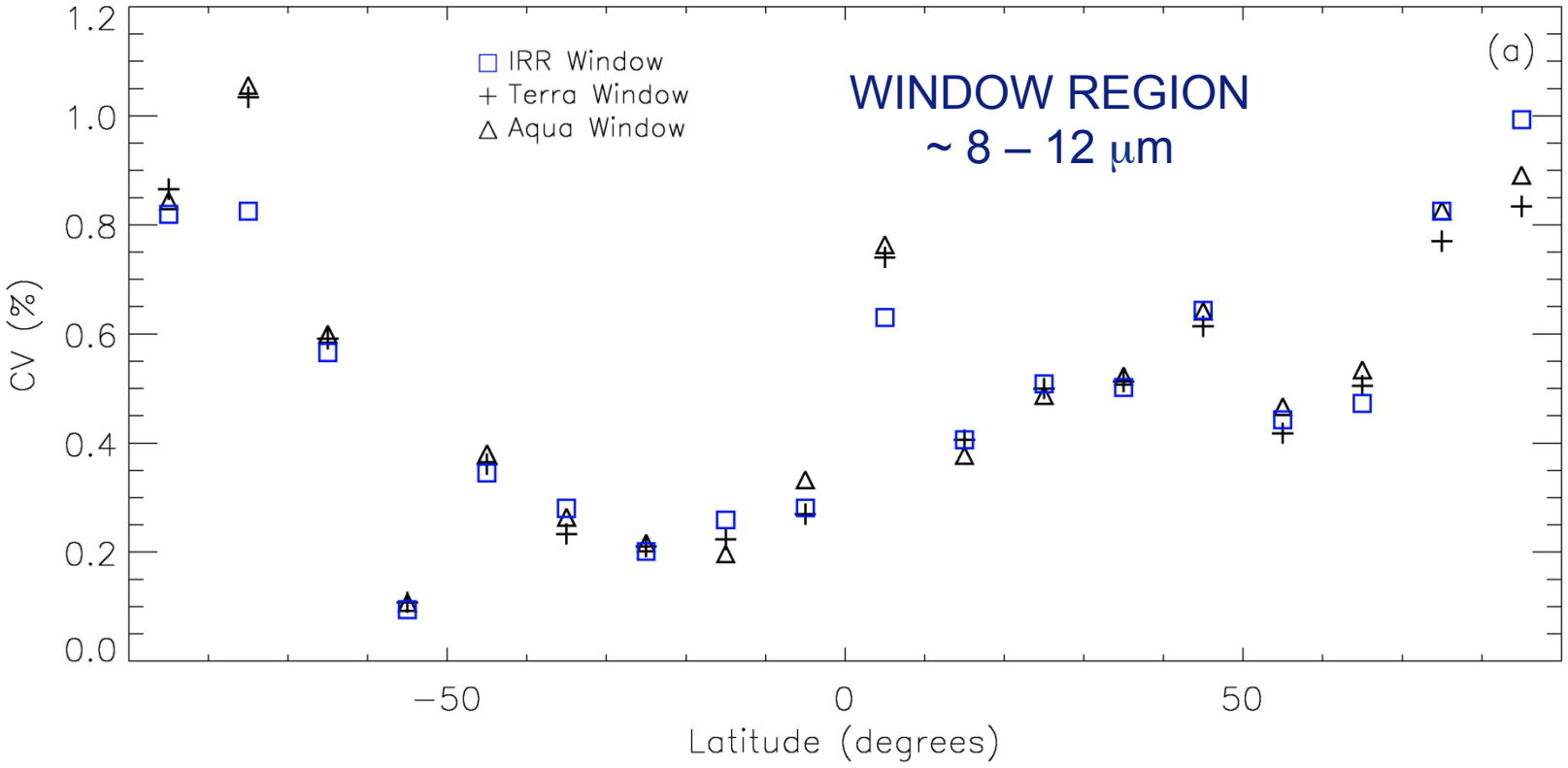


Consistency with broadband measurements?

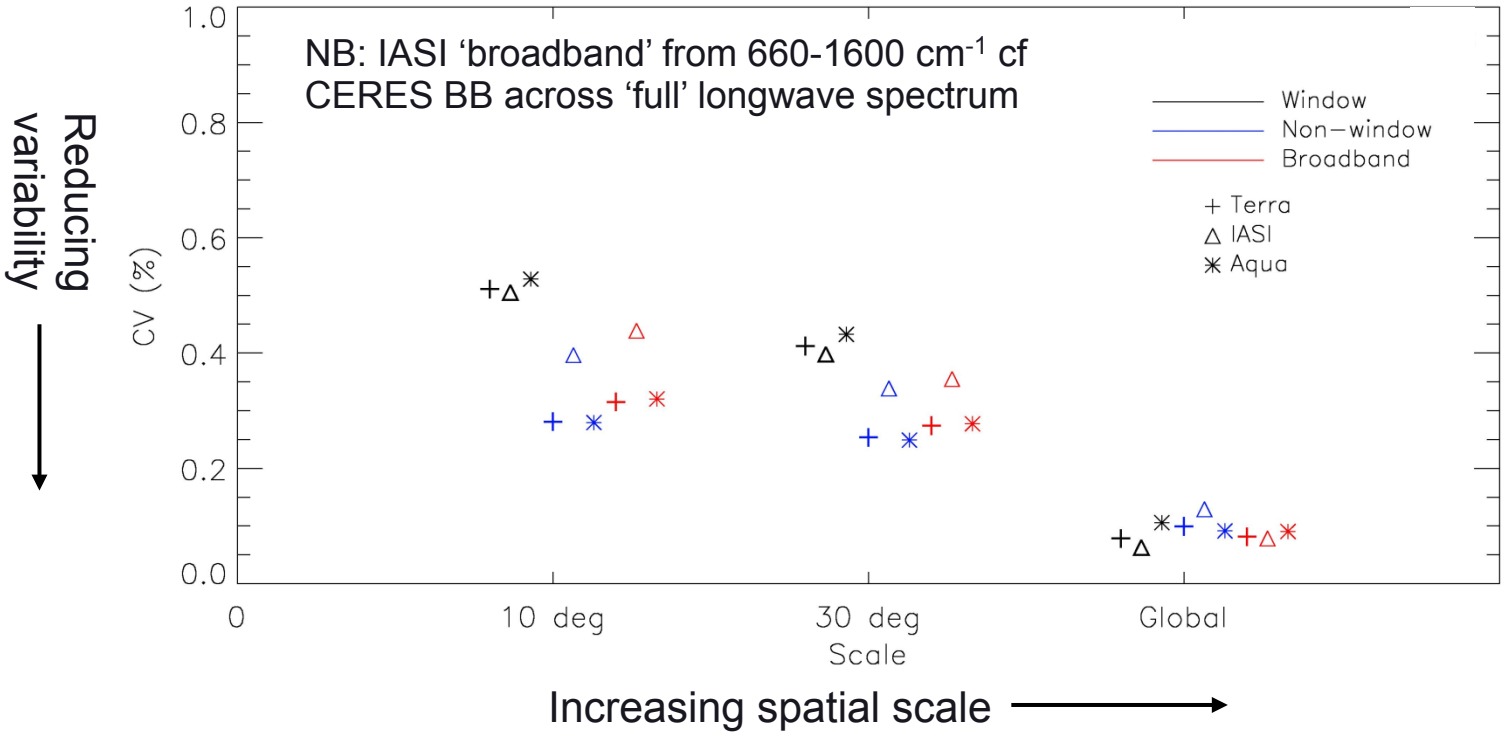
Employ observations from CERES: broadband and window ***fluxes***

Different measurement scales so use ***coefficient of variation, CV***

$CV = \sigma / \mu$ and note that $\sigma_{BB} = [\sigma_{win}^2 + \sigma_{nonwin}^2 + 2cov_{win,nonwin}]^{1/2}$



Consistency with broadband measurements?

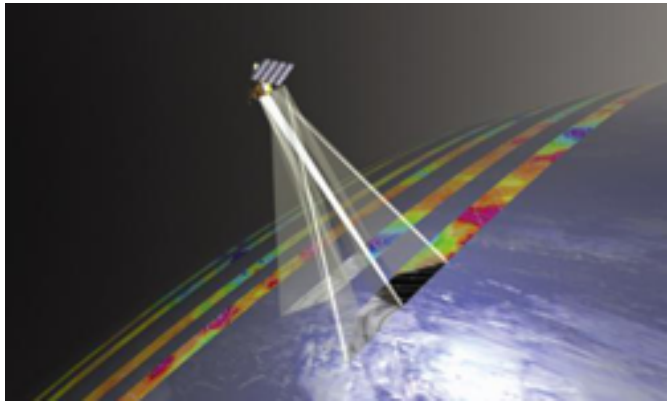


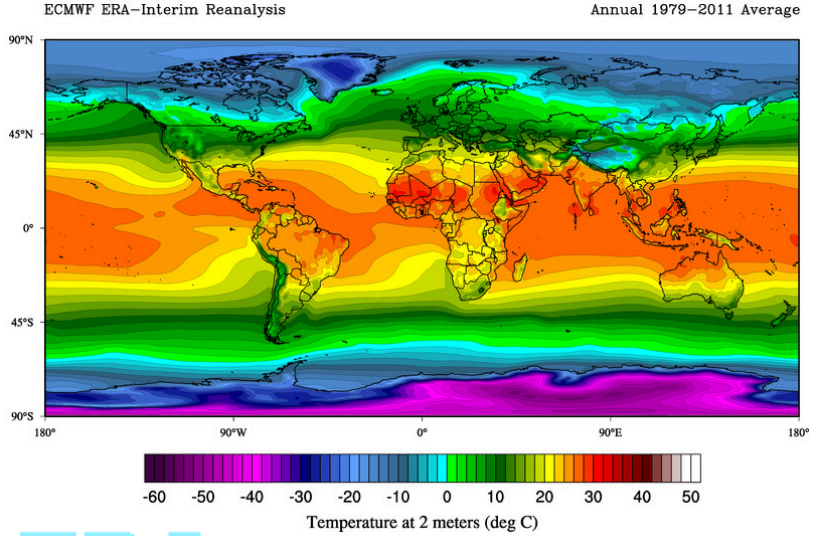
- Window inter-annual variability reduces most rapidly with increasing scale
- Results in non-window variability becoming dominant at global scale
- Difference between IASI BB and CERES BB behaviour suggests an important role for the far infra-red in determining all-sky inter-annual variability at the global scale
- Spectrally, global inter-annual variability < 0.17 K, < 0.05 K across window

Major Questions

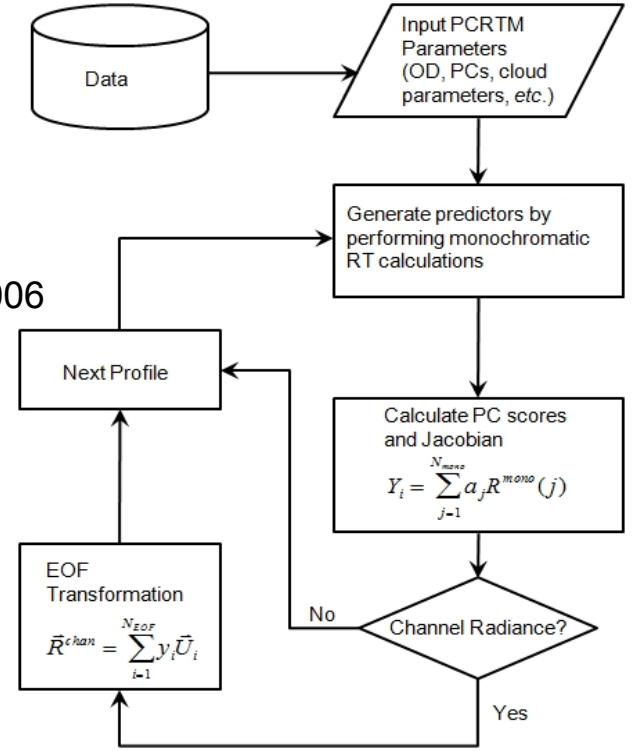
- What is the short-term variability seen in observed radiance spectra?
- How do these signals compare to those seen in model simulations and what can this tell us about the representation of the processes driving variability/change?
- Are observed long-term change signals robust?

Consistency with Reanalyses?





PCRTM
Liu *et al.*, 2006



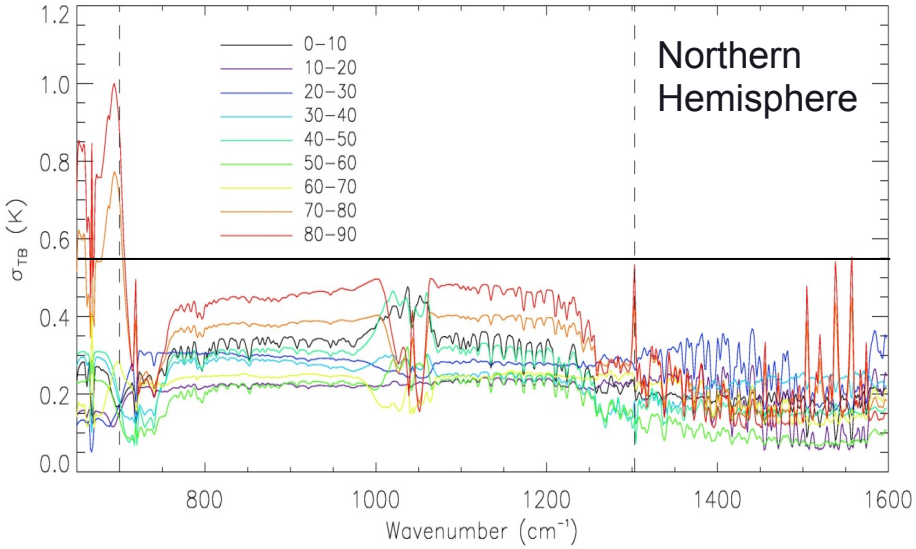
X. Huang, University of Michigan

~ 10 million matched IRIS-like IASI spectra (in 10 days!)

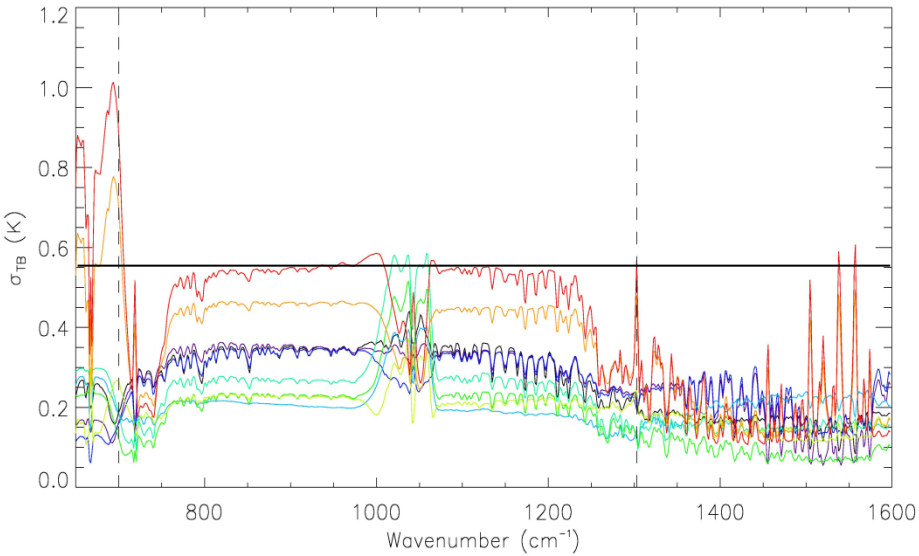
Consistency with Reanalyses?

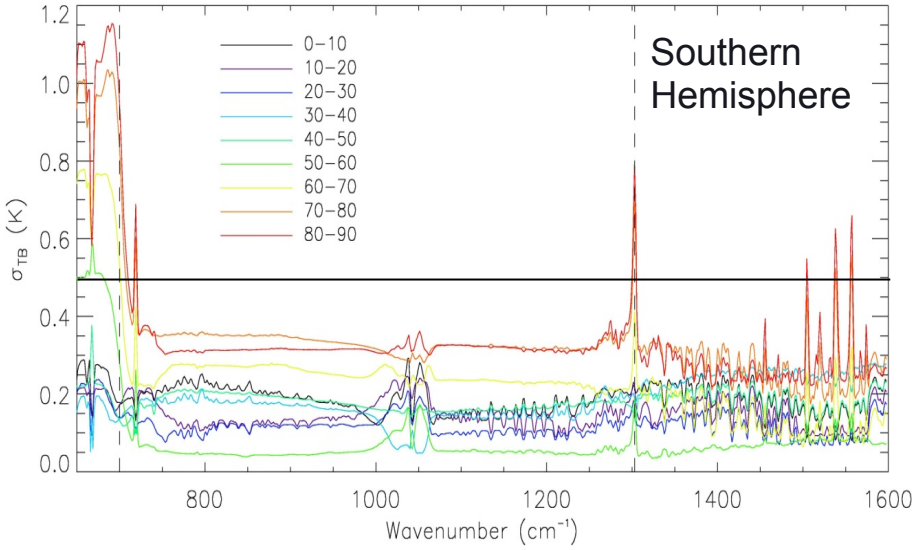
10° bands

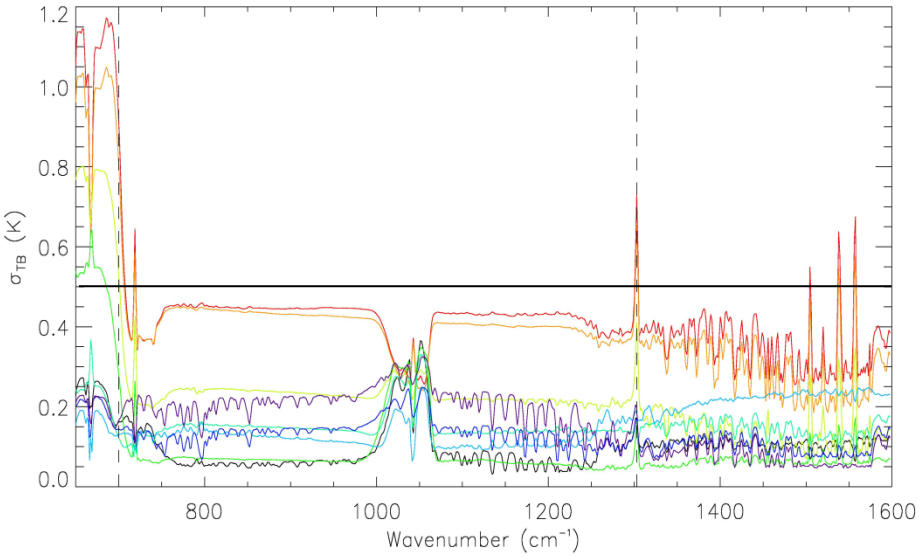
OBSERVATIONS



SIMULATIONS



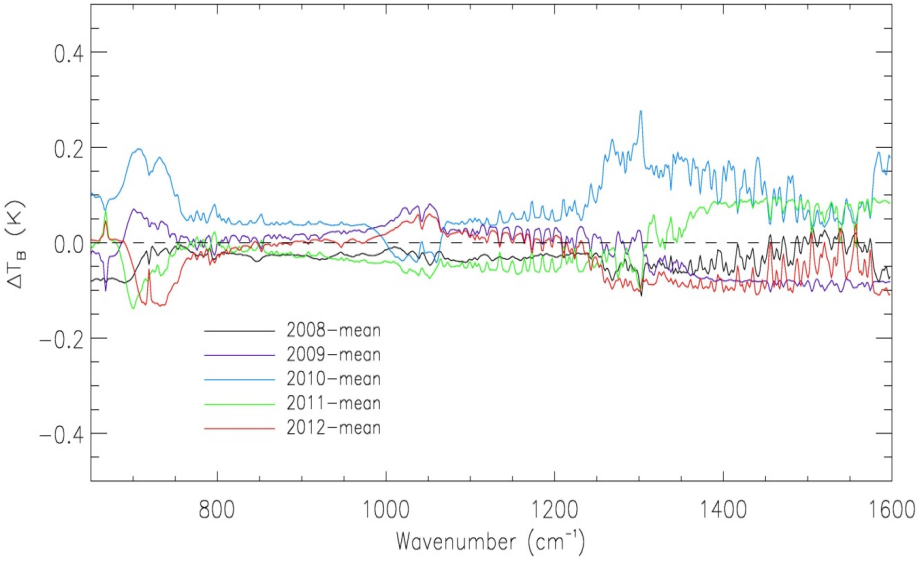




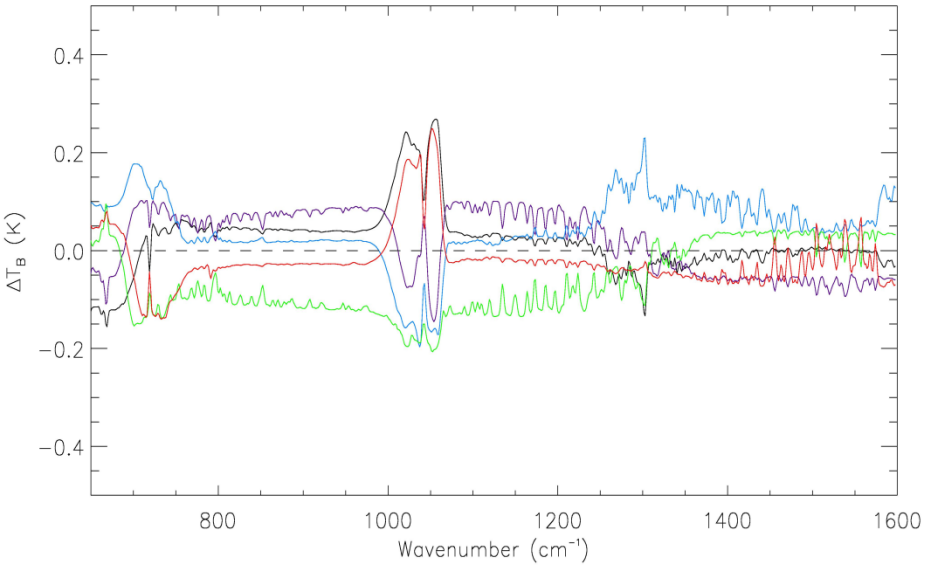
Consistency with Reanalyses?

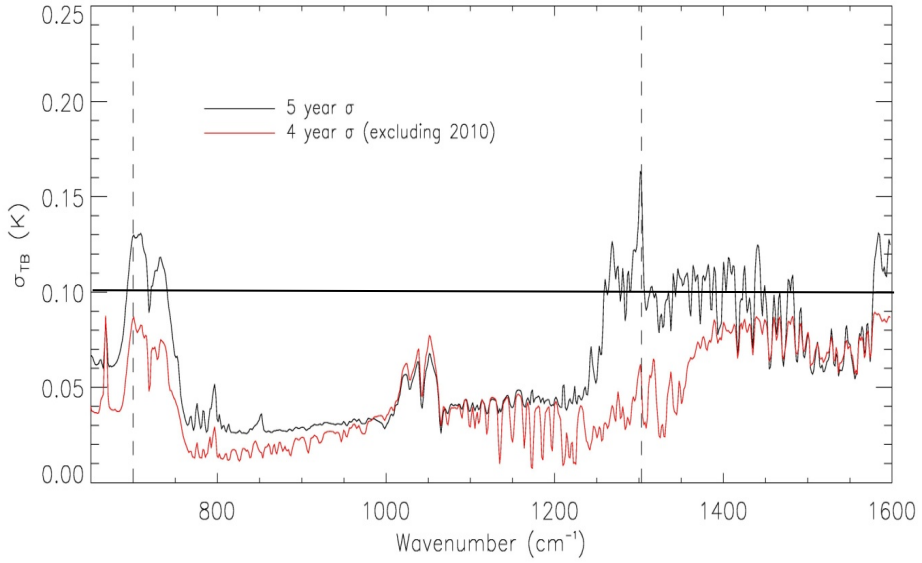
Global

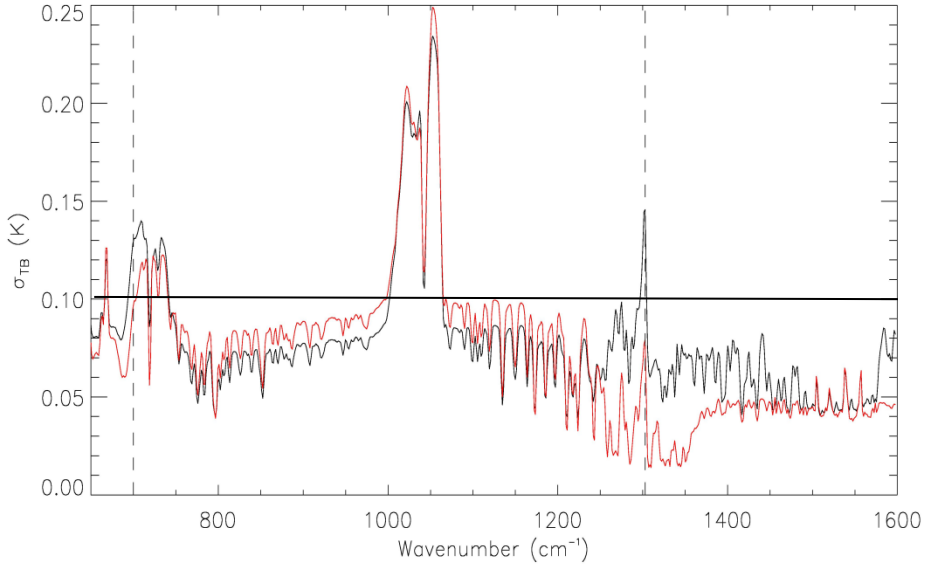
OBSERVATIONS



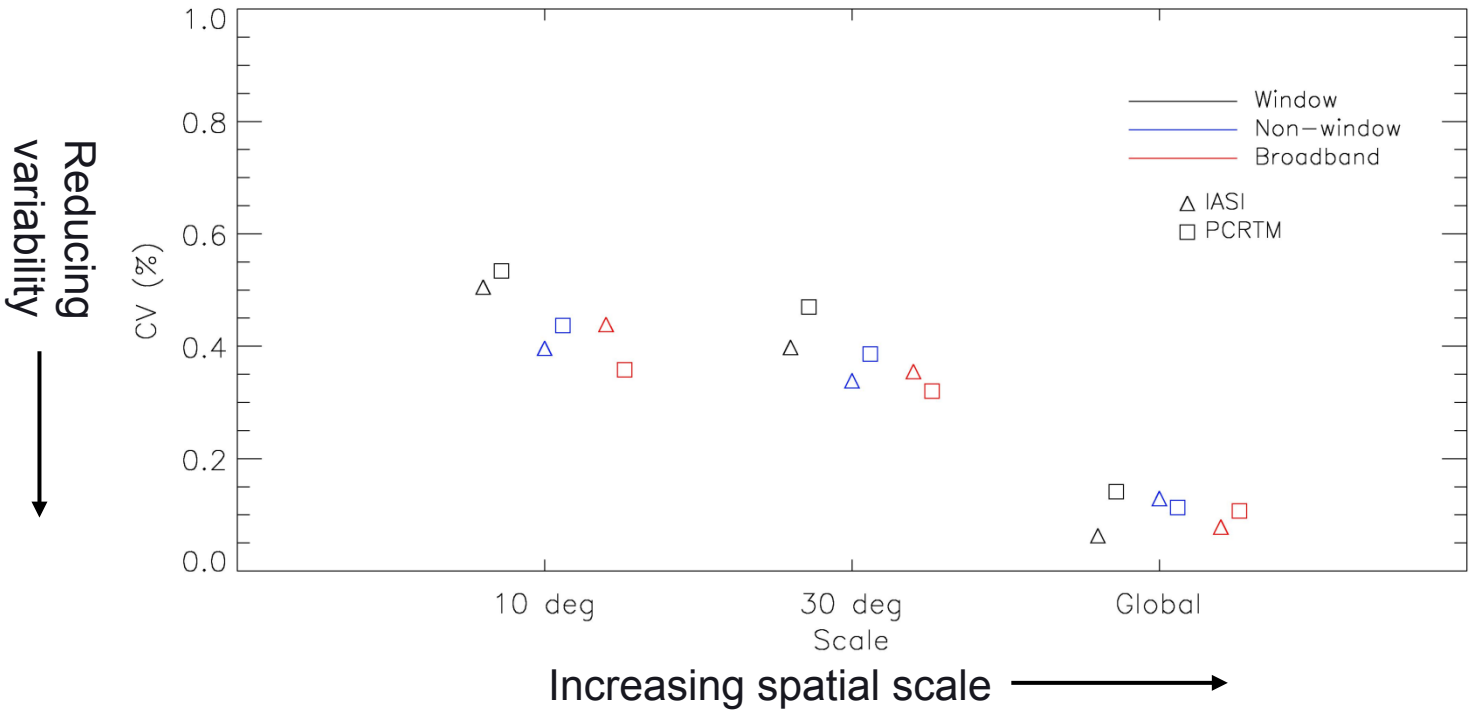
SIMULATIONS







Consistency with Reanalyses?



- Window inter-annual variability reduces most rapidly with increasing scale

  Simulations show the same behaviour but reduction in window is not as rapid. Non-window variability exceeds broadband at all scales and seems to show a faster rate of change with scale than observations

- Results in non-window variability becoming dominant at global scale

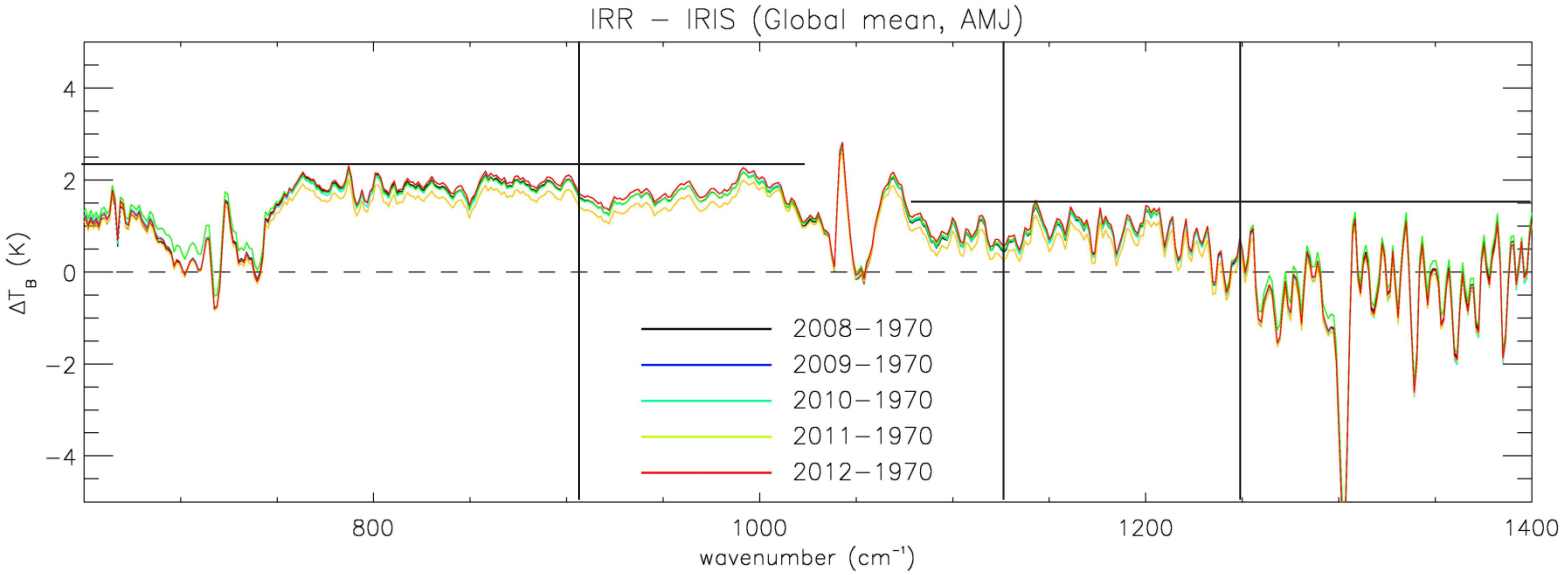
  Window variability still dominates at global scale

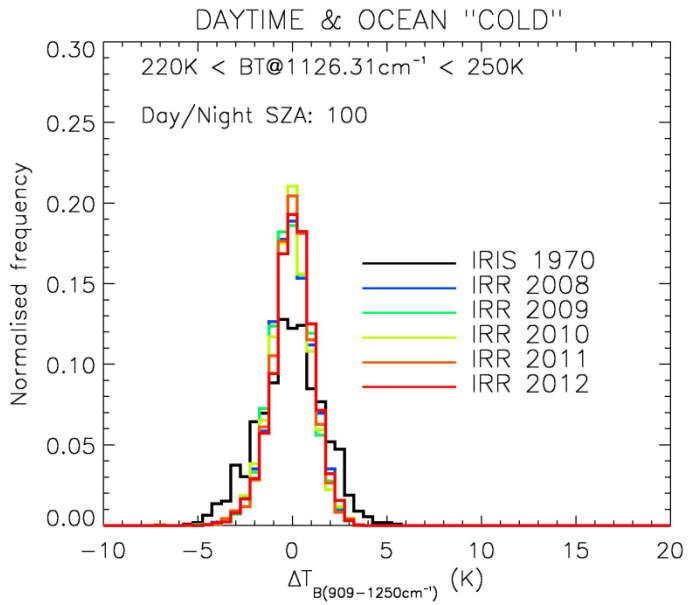
- Spectrally, global inter-annual variability < 0.17 K, < 0.05 K across window

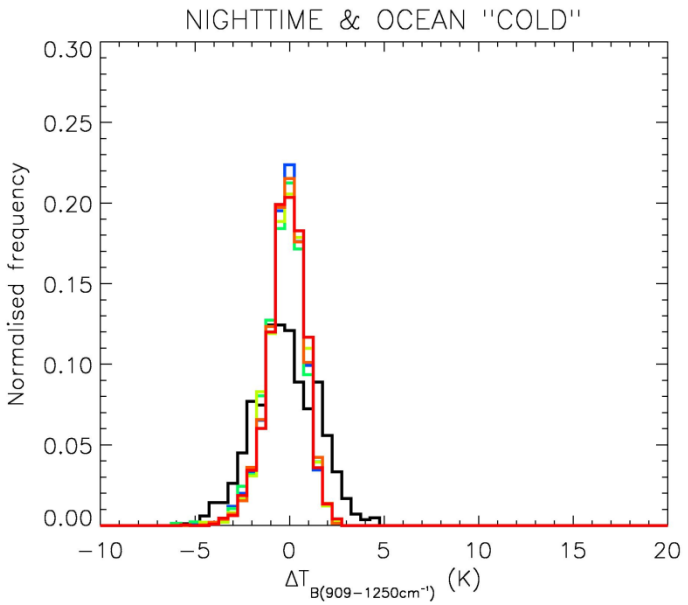
  Variability < 0.15 K but up to 0.08 K within window

Major Questions

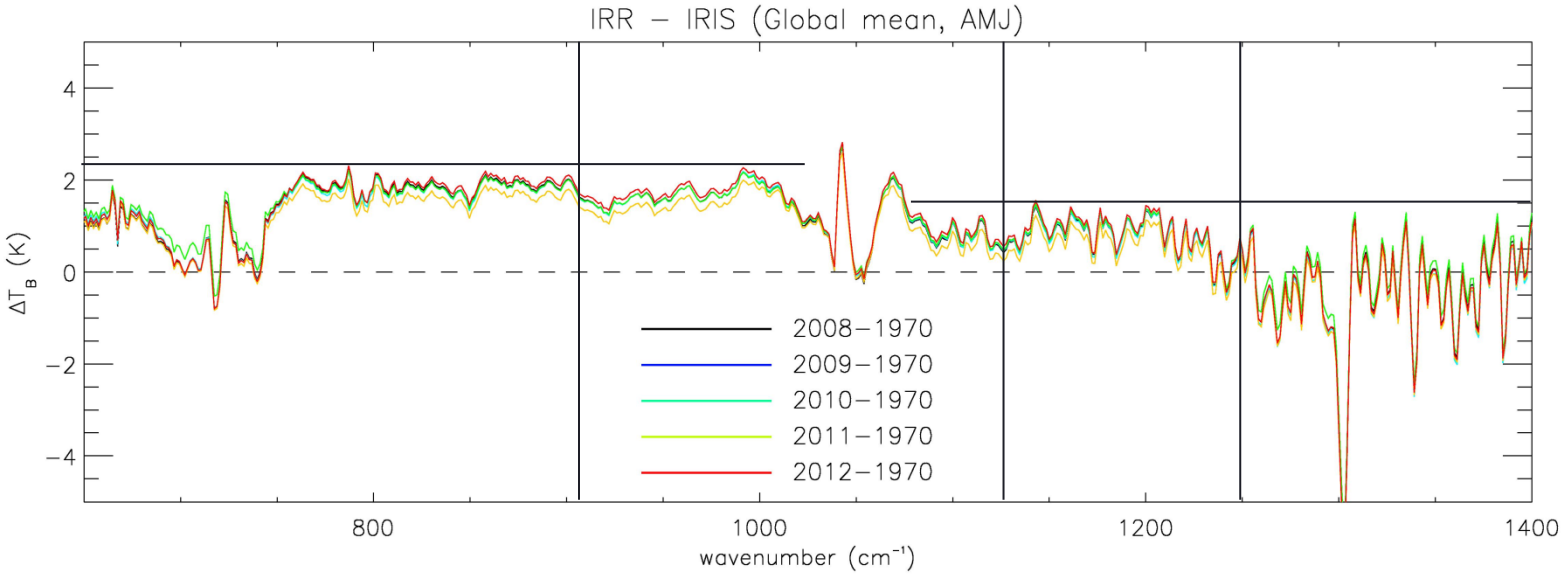
- What is the short-term variability seen in observed radiance spectra?
- How do these signals compare to those seen in model simulations and what can this tell us about the representation of the processes driving variability/change?
- Are observed long-term change signals robust?

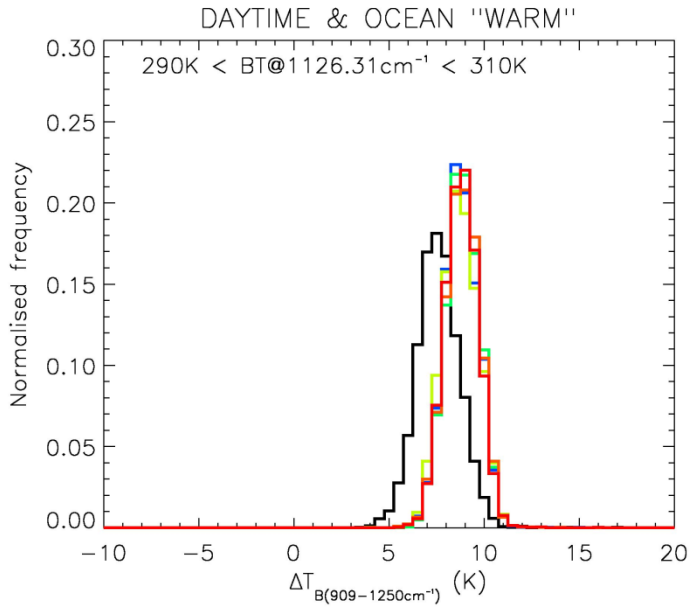


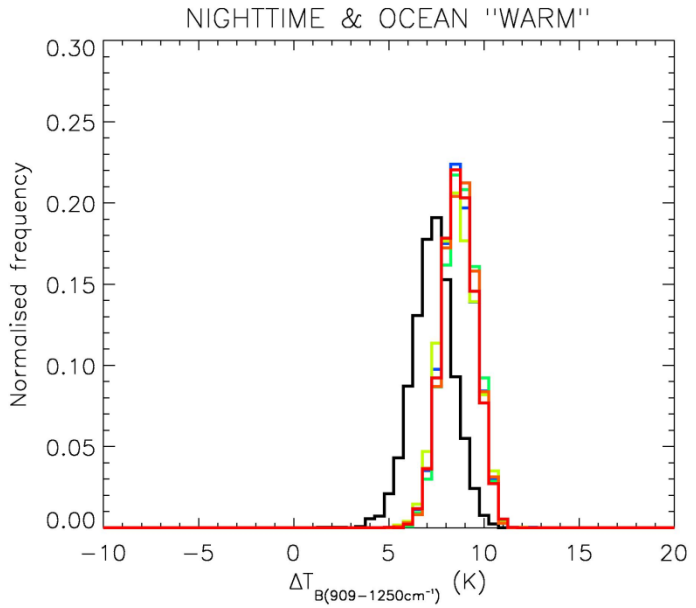




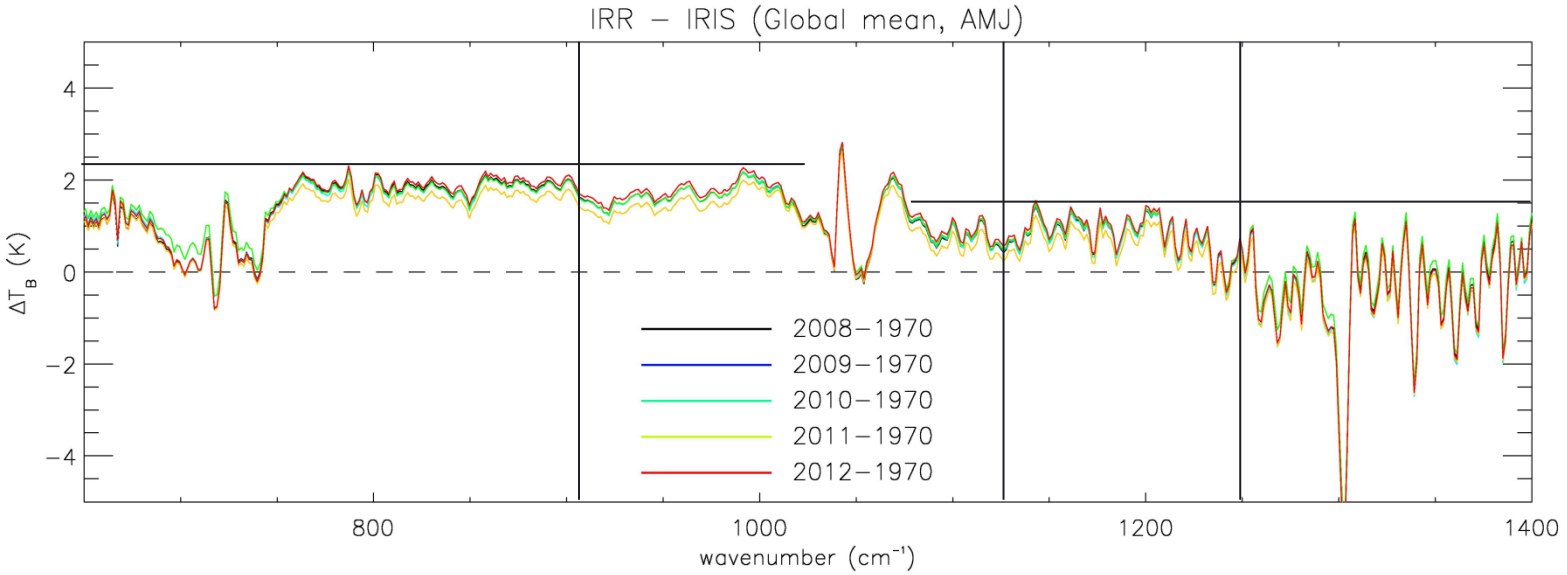
Ocean only scenes, 220 K < T_{B1126} < 250 K, IRR & IRIS

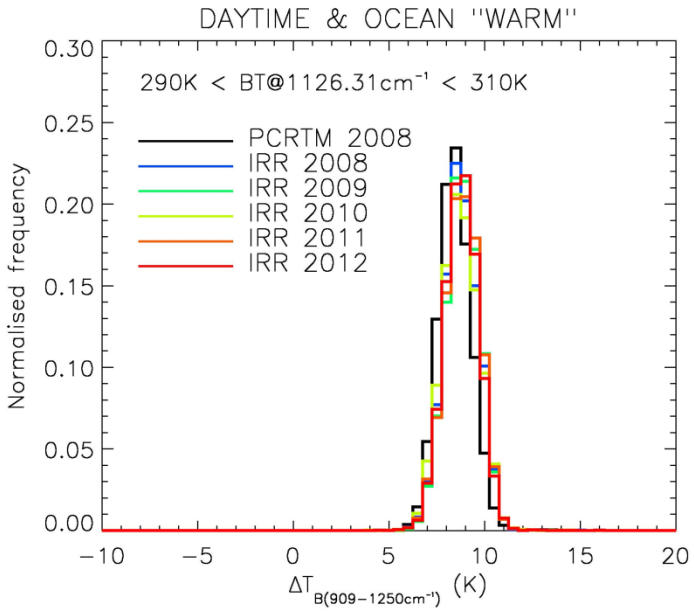


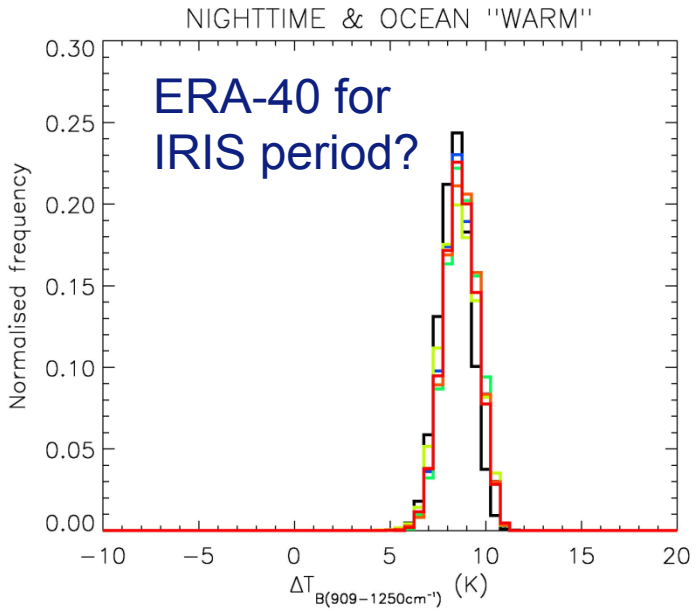




Ocean only scenes, 290 K < T_{B1126} < 310 K, IRR & IRIS

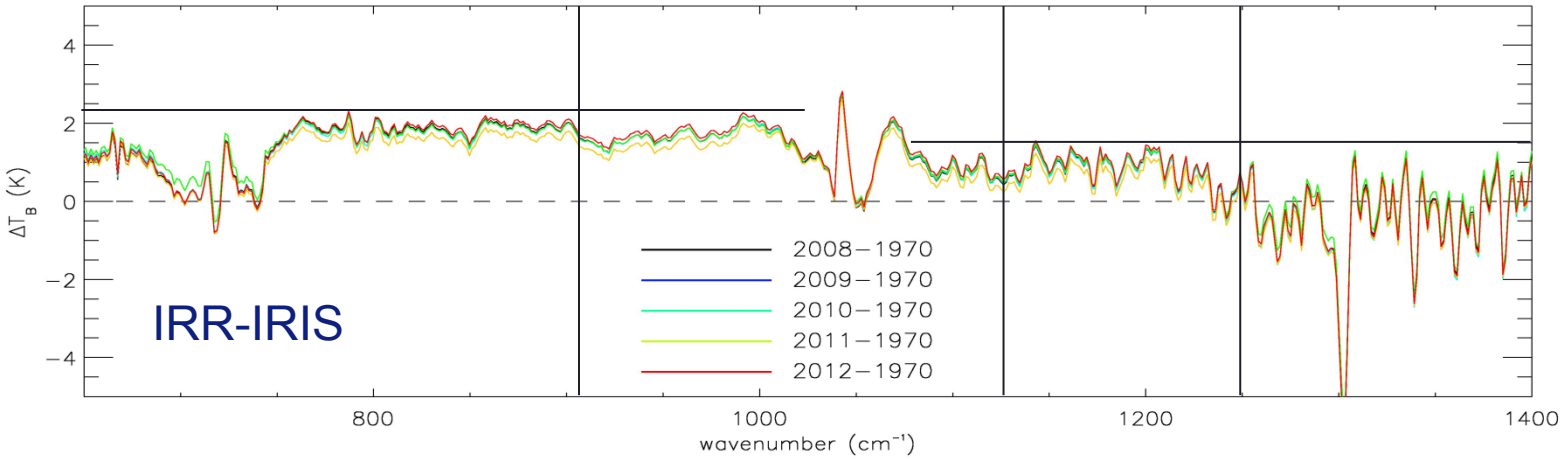


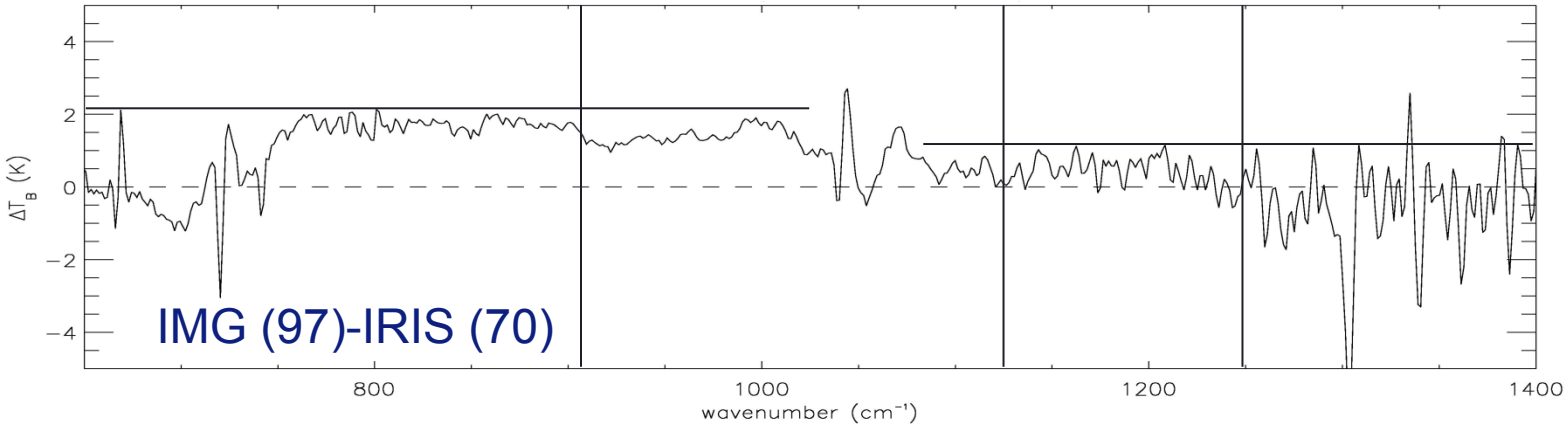


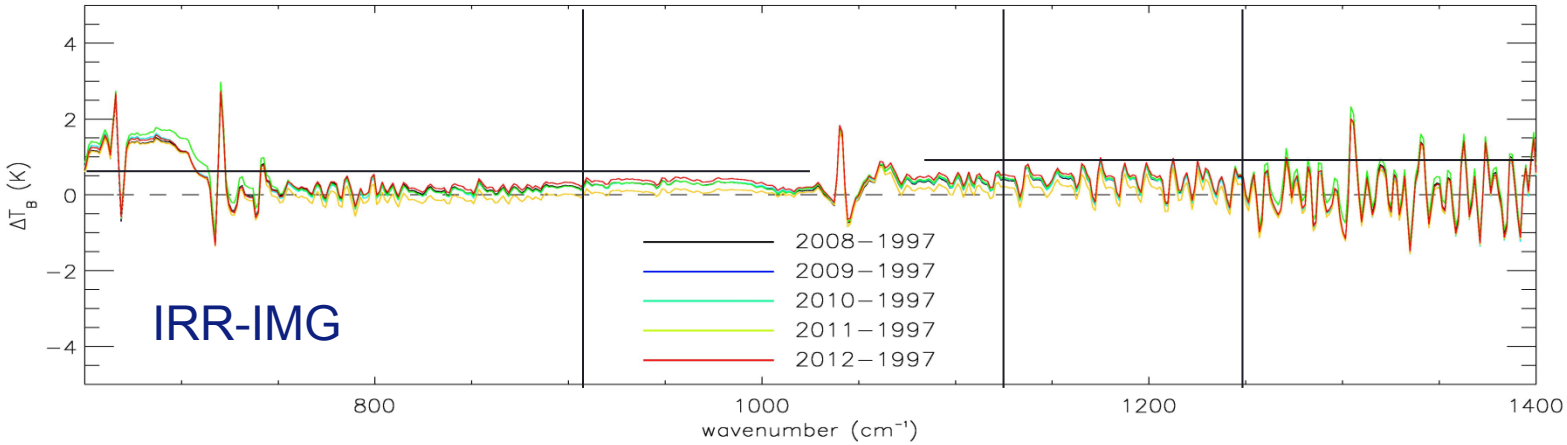


Ocean only scenes, 290 K < T_{B1126} < 310 K, IRR & PCRTM

Global Mean AMJ T_B difference spectra







Summary

- Used IASI data to probe how the emission to space varies spectrally on short timescales. While variability reduces with increasing spatial scale across the spectrum, the rate of change varies with wavenumber. Hence a more marked reduction is seen in window variability compared to that seen in regions sensitive to the upper troposphere.

- These findings are in agreement with observations from CERES over the same period and imply that at the largest spatial scales fluctuations in mid-upper tropospheric temperatures and water vapour, and not surface temperature or cloud, play the dominant role in determining the level of inter-annual all-sky OLR variability.

  (Brindley et al., *J. Clim*, in review)

- Although simulations from reanalysis show an encouraging level of agreement in general, they do not replicate this scaling behaviour.

- To diagnose longer term spectral changes confidence in instrument calibration and stability is key.

TRUTHS/NCEO status

- New Minister for Universities and Science from July 2014 (Greg Clark): national/bilateral mission opportunities unlikely before UK general election.

- Presentations made to Mark Walport (Government Chief Scientific Advisor), Ian Boyd (Chief Scientific Advisor at DEFRA), Outgoing DECC Chief Scientist. DECC Climate Minister visiting NPL in November.

- Joint bid with Airbus-DS for TRUTHS related funding in latest CEOI round (£1M budget). [Note that Imperial has also submitted a bid for FIR instrument development to same call].

- Formal letter of support for TRUTHS from NASA HQ?

- Ongoing CASE PhD studentship with Imperial to strengthen science case.

- Studies supporting CLARREO funded until at least April 2015 via NCEO (new director: John Remedios; HB now joint head of Earth Observation Data and Model evaluation division). Should be opportunities for continued funding for TRUTHS/CLARREO science support.